It is possible, however, that the disparity is due to the method of stimulus presentation. In the earlier study, a 3-inch frame was used, the standard being shown for the first half of the frame, the comparison for the second. The increment in velocity (if any) was added instantaneously at the center of the oscilloscope face. Accordingly, the actual acceleration (visually, the "jerk") provided a cue, in addition to the disparity in isometric traverse time. One intriguing speculation is that these subjects may have treated the problem as one requiring a judgment concerning the presence or absence of "jerk," instead of as a comparison of two velocities or two traversal times. Behaviorally, the psychophysical judgment for the subjects in the earlier tests may have been that for the absolute threshold of acceleration instead of that for the difference threshold of velocity, even though mathematically the two stimulus conditions are, of course, equivalent.

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4 December 1959

Recognition of Paired Trigrams as a Function of Associative Value and Associative Strength

Abstract. The accuracy of visual recognition of tachistoscopically presented paired nonsense trigrams was shown to vary directly with the associative value and associative strength. Parallel results were previously reported for meaningful verbal material. It is argued that the same perceptual processes underlie the learning of nonsense and of meaningful material.

Perceptual processes that apply to the visual recognition of meaningful words (*1*) should apply also to the recognition of nonsense trigrams. This report shows that verbal performance is related to accuracy of recognition of nonsense verbal material, as measured by associative value and associative strength (*2*).

Associative value refers to the degree to which a trigram composed by a consonant, a vowel, and a consonant suggests words within a given period of time—for example, 30 seconds. The value of each nonsense trigram is determined by the percentage of subjects who associate meaningful words to it, the value ranging from 0 to 100 percent. Associative value, therefore, is a measure of response evocation.

Associative strength refers to the degree of bond linking a stimulus trigram to a response trigram. The degree of bond and consequent ease of learning of a pair is determined by a variety of intercorrelated measures needed to meet a criterion of learning, usually one errorless repetition of a list of such paired trigrams presented on a memory drum. The most frequently used measures of associative strength are number of trials or of correct responses to criterion. Both measures are highly correlated with each other (mean $r = .94$) and both are related inversely to the associative strength of each pair of trigrams (*2*). Associative strength, therefore, is a measure of response acquisition or of response strengthening for both the stimulus and response terms of a paired trigram.

The relationship between associative value and associative strength of paired nonsense trigrams has been summarized as being nonlinear and nonadditive. Associative strength increases geometrically as the associate values of each pair increase. The higher the associative values of the stimulus and of the response, the easier it is to learn the pair of syllables—that is, the smaller the number of trials to the criterion of learning (*2*). This relationship is shown in the first part of Table 1.

Table 1. Associative values, associative strength, and mean number (± standard deviation) of correct recognitions for paired nonsense trigrams (consonant, vowel, consonant).

Associative values		Associative strength (No. of trials to criterion)	Correct visual recognitions (No.)		
Left	Right		Left	Right	Left + Right
100	100	13.43 ± 6.56	2.38 ± .34	1.63 ± .52	4.01 ± .68
0	100	16.81 ± 4.61	2.06 ± .39	1.44 ± .60	3.50 ± .75
47	47	19.00 ± 6.84	2.01 ± .37	1.33 ± .58	3.34 ± .81
100	0	22.47 ± 5.65	2.19 ± .46	1.34 ± .52	3.53 ± .71
0	0	34.57 ± 9.53	1.96 ± .41	1.21 ± .40	3.17 ± .63

To find how visual recognition of paired nonsense trigrams is related to associative value and to associative strength, the procedure outlined by Heron (*3*) was followed: three lists of 116 pairs of nonsense syllables were typewritten in upper case letters. One trigram was presented to the left of a fixation point, the other to the right. Thus, six letters were shown at a time. The pairs had been originally ranked on the basis of their associative values and their associative strength. Five combinations of associative values for the left and right syllables were used: 100–100, 0–100, 47–47, 100–0, and 0–0 (*2*).

The pairs were projected tachistoscopically on a glass-beaded, white screen that was uniformly illuminated by a 60-watt bulb at a distance of 5 feet. The angle subtended at the retina by both trigrams was 8°26′. The tachistoscope was a Keystone overhead projector furnished with a Keystone No. 4 universal flashmeter set to expose both syllables simultaneously at 1/100 second. The exposure time for each pair was kept constant throughout the three sessions (one session for each of the three lists). The intensity of the light was adjusted during the presentation of five practice pairs of trigrams that preceded the presentation of the experimental pairs.

The order of presentation within each list was reversed from subject to subject and from session to session to counterbalance serial and fatigue effects. After the presentation of each pair, the subjects were asked to spell out the materials presented to them immediately from left to right, even if they had to guess.

The subjects were 15 men and 15 women from the professional staff of a medical institution. The ages of the men ranged from 22 to 32 years. The ages of the women ranged from 20 to 50 years. Most subjects were in their late 20's. None reported gross visual defects. Ten men and eight women wore corrective glasses.

The results of mean correct visual recognitions as a function of the associative values and associative strength of the trigrams are summarized in Table 1. The mean number of correct recognitions decreases from four out of six for 100–100 associative values to slightly more than three per pair for associative values of 0–0. An analysis of variance performed on the mean number of total (left plus right) correct recognitions yielded a highly significant F-ratio of 15.61 ($p < .01$) for the means of the five combinations of associative values studied. The greatest part of the between-variance (11.87) was caused by a linear component (10.18).

To find the relationship between visual recognition and associative strength, only two lists of nonsense trigrams were used. The pairs of the third list could not be ranked reliably according to associative strength. A first list of 40 trigrams of 47–47 associative values yielded a nonsignificant rank-order correlation between the mean number of correct recognitions and the mean number of trials to criterion ($r = .21$). A second list of 40 pairs (10 pairs for each of the following combinations: 100–100, 0–100, 100–0, and 0–0), ranked according to the mean number of correct responses per pair within ten learning and ten transfer trials (*4*), yielded a positive and significant rank-order correlation with the mean number of correct recognitions ($r = .41$, $p < .05$).

Another factor determining the accuracy of recognition was found to be retinal locus. The mean number of correct recognitions was greater to the left than to the right of the fixation point. These results are similar to those reported by Heron (*3*). He found a more accurate recognition in the left visual field than in the right field, when three English letters were exposed simultaneously rather than successively on either side of the fixation point. Such a "differential recognition" was attributed to "the dominant tendency to move the eyes to the beginning of the line" (*3*, p. 47). In addition to associative value and associative strength as determinants of visual recognition of nonsense trigrams, retinal locus should also be taken into consideration in studying visual recognition of nonsensical and of meaningful materials (*5*).

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4. This measure is related inversely to the number of trials or of correct responses to a learning criterion (the mean coefficients of correlation with these measures are –.74 and –.62 respectively).
5. This experiment was conducted during my tenure as U.S. Public Health Service postdoctoral fellow at the Institute for Psychosomatic and Psychiatric Research and Training of Michael Reese Hospital, Chicago, Ill.

21 January 1960

Extracellular Invertase Production by Sexually Agglutinative Mating Types of Saccharomyces kluyveri

Abstract. Unisexual strains of both mating types of *Saccharomyces kluyveri* produce exceedingly high yields of extracellular invertase. Yields generally increase with an increase in the number of sets of chromosomes possessed by the unisexuals. The bisexual forms give small amounts in comparison.

In 1956 Wickerham reported the agglutination of opposite sexes in the yeast *Hansenula wingei* Wickerham (*1*). He coined the term "sexual agglutination" (*2*) to differentiate agglutination by opposite mating types from mutual agglutination. The latter process is a much weaker reaction discovered by Eddy (*3*) in strains of brewery yeasts. Both strains of the mutually agglutinative pair (NCYC 74 and 1109) which we obtained from Eddy proved to be bisexual. Recently, Brock (*4*) presented evidence that sexual agglutination in *H. wingei* is due largely to the presence of a specific protein on the cell wall of one of the sexes that reacts with a specific polysaccharide on the cell wall of the opposite sex. He believes the reaction is comparable to that of antigen with its specific antibody. Sexual agglutination is also known to occur in sea urchins and in a few species of algae and protozoa. In these, likewise, there is evidence of stereospecific reactions.

Wickerham (*2*) has reported the occurrence of sexual agglutination in species of four genera of yeasts. The most highly developed species are in *Saccharomyces*, as judged by the ease with which unisexual diploids and presumably unisexual polyploids are produced, as well as by the copious formation of bisexual tetraploids and presumably bisexual hexaploids and octaploids.

Contrary to the generally accepted belief that yeasts do not produce extracellular invertase, we have shown that certain yeasts actually do produce significant amounts (*5*, *6*). The maximum yields of extracellular invertase from *Saccharomyces uvarum* NRRL Y-972 were 126 units per milliliter in aerobic (shaken) culture and 50 units per milliliter in anaerobic (still) culture. Enzyme activity was measured by the procedure of Sumner and Howell (*7*), with slight modification (*6*).

In the present study, bisexual forms of *Saccharomyces kluyveri* Phaff, Miller, and Shifrine (*8*) were found to produce low yields of extracellular invertase commensurate with yields by unisexuals and bisexuals of industrially important species of *Saccharomyces* (*S. cerevisiae*, *S. carlsbergensis*, and *S. diastaticus*). The unisexuals of *S. kluyveri*, however, gave astonishingly high yields (Table 1). Unisexuals 7H1 and 7H2 are two haploids of one sex, and 13H1 and 13H2 are two haploids of the opposite sex. Unisexual diploids 7D1 and 13D1 were derived from 7H1 and 13H1, respectively. Unisexuals designated by code numbers also were largely derived from ascosporic isolates 7 and 13, and are presumed to be triploids and tetraploids. There seems to be a general increase in yields of invertase with an increase in number of sets of chromosomes possessed by the unisexuals. With increasing ploidy the unisexuals also increase in intensity of sexual agglutination; so much so, that presumably unisexual polyploids often show some agglutination by themselves in liquid culture. The ratio of invertase

Table 1. Production of extracellular invertase in aerobic and anaerobic cultures by bisexual and unisexual forms of the sexually agglutinative species *Saccharomyces kluyveri* NRRL Y-4288.

Sex and ploidy	Extracellular invertase	
	Aerobic (unit/ml)	Anaerobic (unit/ml)
Parent bisexual	26	
Bisexual		
Diploid		
7H1 × 13H1	15	
7H1 × 13H2	13	
7H2 × 13H1	13	
7H2 × 13H2	17	
Triploid		
7H1 × 13D1	13	
7H2 × 13D2	14	
7D1 × 13H1	20	
7D2 × 13H2	24	
Tetraploid		
7D1 × 13D1	13	
7D1 × 13D2	24	
7D2 × 13D1	22	
7D2 × 13D2	25	
Unisexual		
Haploid		
7H1	298	
7H2	297	
13H1	366	
13H2	253	
Diploid		
7D1	313	
7D2	337	
13D1	351	
13D2	361	
Presumed unisexual polyploid		
Code 3	792	163
Code 4	491	267
Code 7	295	182
Code 12	340	214
Code 15	380	224
Code 17	340	232
Code 18	279	434
Code 20	580	201
Code 24	325	419
Code 25	385	465
Code 26	492	173
Code 27	230	248
Code 3, transferred serially 2 months	800	
Code 26, transferred serially 3 months	456	